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Idaho Operations Office

In Situ Bioremediation Operations and Maintenance Plan for Test Area North, Operable Unit 1-07B

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In Situ Bioremediation Operations and Maintenance Plan for Test Area North, Operable Unit 1-07B

March 2004

Prepared for the
U.S. Department of Energy
Idaho Operations Office

ABSTRACT

This Operations and Maintenance Plan supports the *In Situ Bioremediation Remedial Action Work Plan for Test Area North Final Groundwater Remediation, Operable Unit 1-07B* and identifies the approach and requirements for in situ bioremediation operations and maintenance activities during the Operable Unit 1-07B final remedial action. The final remedial action covers the implementation of all components of the contaminated groundwater plume restoration at Test Area North of the Idaho National Engineering and Environmental Laboratory. In accordance with the *Record of Decision Amendment Technical Support Facility Injection Well (TSF-05) and Surrounding Groundwater Contamination (TSF-23) and Miscellaneous No Action Sites, Final Remedial Action*, in situ bioremediation and monitored natural attenuation remedy components for the hot spot and distal zone of the plume were added due to successful alternate technology treatability studies. The scope of this Operations and Maintenance Plan focuses on the in situ bioremediation portion of the remedy and includes in situ bioremediation injection facility operations and maintenance and the associated sampling and analysis, data evaluation, remedy performance reviews, and the final In Situ Bioremediation Operations and Maintenance Report.

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ACRONYMS

ANSI	American National Standards Institute
ARD	anaerobic reductive dechlorination
BLM	U.S. Bureau of Land Management
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	contaminant of concern
CWSA	CERCLA waste storage area
DCE	dichloroethene
DOE	U.S. Department of Energy
INEEL	Idaho National Engineering and Environmental Laboratory
ISB	in situ bioremediation
LST	list
MCL	maximum contaminant level
MCP	management control procedure
NE-ID	U.S. Department of Energy Idaho Operations Office
O&M	operations and maintenance
OU	operable unit
PCE	tetrachloroethene
RAO	remedial action objective
STD	standard
TAN	Test Area North
TCE	trichloroethene
TPR	technical procedure
TSF	Technical Support Facility
VC	vinyl chloride
VOC	volatile organic compound

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In Situ Bioremediation Operations and Maintenance Plan for Test Area North, Operable Unit 1-07B

1. INTRODUCTION

The U.S. Department of Energy Idaho Operations Office (NE-ID)[a] has prepared this Operations and Maintenance (O&M) Plan in accordance with the *Federal Facility Agreement and Consent Order for the Idaho National Engineering Laboratory* (DOE-ID 1991). This plan addresses O&M aspects of the in situ bioremediation (ISB) hot spot remedial action for the Test Area North (TAN) Technical Support Facility (TSF) injection well, TSF-05, and surrounding groundwater contamination, TSF-23. These areas have been designated as Operable Unit (OU) 1-07B. This O&M Plan was prepared in support of the *In Situ Bioremediation Remedial Action Work Plan for Test Area North Final Groundwater Remediation, Operable Unit 1-07B* (DOE-ID 2003) and in accordance with the *Remedial Design/Remedial Action Scope of Work Test Area North Final Groundwater Remediation Operable Unit 1-07B* (DOE-ID 2001a).

This O&M Plan addresses the activities and requirements for operations and maintenance during the four phases (interim, initial, optimization, and long-term operations) of the OU 1-07B hot spot remedial action. Operational information presented in this plan includes the ISB implementation strategy, the required operational resources, operational procedures and protocols, and the data evaluation process. A table summarizing the Agency review comments, and the associated comment resolutions that were incorporated into this document, can be found in Appendix D.

1.1 In Situ Bioremediation Objectives

As described in the In Situ Bioremediation Remedial Action Work Plan (DOE-ID 2003), the implementation of the hot spot remedial action includes the design, construction, and operation of an ISB amendment injection and monitoring system. Periodically, the ISB system will inject amendments into the aquifer's source area to facilitate anaerobic reductive dechlorination (ARD) of volatile organic compounds (VOCs). The remedial action objectives (RAOs), outlined in the *Record of Decision Amendment Technical Support Facility Injection Well (TSF-05) and Surrounding Groundwater Contamination (TSF-23) and Miscellaneous No Action Sites, Final Remedial Action* (DOE-ID 2001b), that apply to ISB are described below:

- Restore the contaminated aquifer groundwater by the year 2095 (100 years from the signature of the 1995 *Record of Decision Declaration for the Technical Support Facility Injection Well [TSF-05] and Surrounding Groundwater Contamination [TSF-23] and Miscellaneous No Action Sites Final Remedial Action, Operable Unit 1-07B* [DOE-ID 1995]), by reducing all contaminants of concern (COCs) to below maximum contaminant levels (MCLs) and a 1×10^{-4} total cumulative carcinogenic risk-based level for future residential groundwater use and for noncarcinogens, until the cumulative hazard index is less than 1.

- Implement institutional controls to protect current and future users from health risks associated with ingestion or inhalation of, or dermal contact with, (1) contaminants in concentrations greater than the MCLs, (2) contaminants with greater than a 1×10^{-4} cumulative carcinogenic risk-based concentration, or (3) a cumulative hazard index of greater than 1, whichever is most restrictive. The

a. The abbreviation NE-ID signifies that the U.S. Department of Energy Idaho Operations Office (which was abbreviated DOE-ID before October 1, 2003) reports to the U.S. Department of Energy Office of Nuclear Energy, Science, and Technology.

institutional controls shall be maintained until all COC concentrations are below MCLs and until the cumulative carcinogenic risk-based level is less than 1×10^{-4}, and for noncarcinogens, until the cumulative hazard index is less than 1. Institutional controls shall include access restrictions and warning signs.

In addition to the RAOs, the ISB system supports the specific ISB performance and compliance objectives outlined in the In Situ Bioremediation Remedial Action Work Plan (DOE-ID 2003) as follows.

The following are performance objectives:

- Achieve electron donor distribution throughout the hot spot and associated biogeochemical reactions

- Achieve source degradation.

The following are compliance objectives:

- Reduce downgradient axial flux from the hot spot as monitored at TAN-28 and -30A such that VOC concentrations are less than MCLs

- Reduce crossgradient transverse flux from the hot spot as monitored at TAN-1860 and -1861 such that VOC concentrations are less than MCLs

- Maintain both downgradient axial flux (TAN-28 and -30A) and crossgradient transverse flux (TAN-1860 and -1861) from the hot spot such that VOC concentrations are less than MCLs.

1.2 In Situ Bioremediation Implementation Strategy

A phased implementation strategy, shown in Figure 1-1, will be used so that key performance parameters (including monitoring secondary source degradation) can be monitored and evaluated during operations, which will then be used during the final phase of operations to determine when RAOs have been achieved. This strategy provides a phased approach designed to show measurable progress toward attainment of the performance and compliance objectives. The four phases—(1) interim operations, (2) initial operations, (3) optimization operations, and (4) long-term operations—are discussed in the following subsections.

1.2.1 Interim Operations

Interim operations will take place during the time period between the approval of the In Situ Bioremediation Work Plan (DOE-ID 2003) and the startup of the ISB system specified in the ISB remedial design, initial operations. Interim operations are a continuation of the activities described in the *In Situ Bioremediation Predesign Operations Work Plan Test Area North, Operable Unit 1-07B* (INEEL 2002a) to support efforts to obtain a better understanding of amendment injection, alternate amendments, and development of injection-monitoring strategies. Interim operations will continue until after completion of the Agency ISB prefinal (or final, if required) inspection for the new ISB injection facility. Interim operations may include the following:

- Continued ISB system operations, including lactate injection and groundwater monitoring.

- Alternate amendment scale-up studies, which will provide operational information required for long-term injection of alternate amendments identified in bench-scale studies.

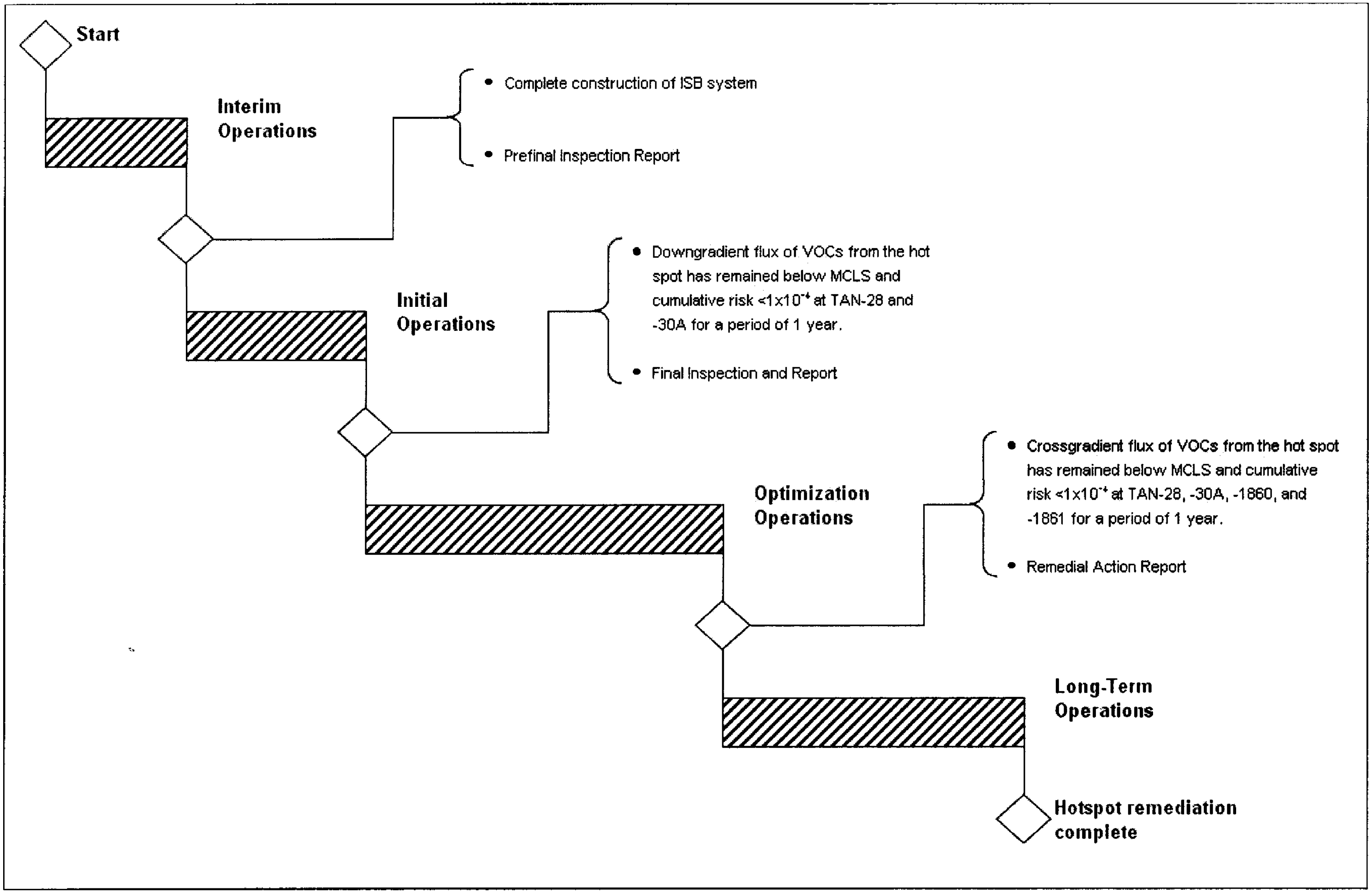

Figure 1-1. Implementation strategy

- Field studies, which will assess different amendment injection strategies. Studies may include varying the frequency, volume, concentration, and location of amendment injection in an effort to improve distribution throughout the residual source area. Studies also may include tracer tests used to determine subsurface flow characteristics in the hot spot area, along with amendment fate and transport parameters.

- Refinement of the ISB performance numerical model, which will incorporate results of the field studies.

1.2.2 Initial Operations

Initial operations will be performed during the first 2 years (approximately) of ISB system operations. During this time, various injection strategies will be used to determine the best method to reduce the downgradient axial flux of chloroethene concentrations leaving the hot spot. At a minimum, quarterly injection events will inject 660 gal of lactate in a 2% equivalent lactate concentration at 20 gpm. Periodic monitoring will be performed throughout this operational phase. Initial operations will be complete when the chloromethane concentrations are below MCLs at the specified downgradient axial well location(s) for 1 year.

1.2.3 Optimization Operations

Optimization operations will comprise the next 5 years (approximately) of ISB operations. During this time, various injection strategies will be used to ensure that both the transverse and axial flux of chloroethene from the hot spot result in concentrations below MCLs at TAN-28, TAN-30A, TAN-1860, and TAN-1861. Optimization operations will be complete when the chloroethene concentrations remain below MCLs at the specified downgradient axial and transverse well locations for 1 year.

1.2.4 Long-Term Operations

Long-term operations will focus on achieving hot spot source degradation, while maintaining chloroethene concentrations below MCLs at TAN-28, TAN-30A, TAN-1860, and TAN-1861.

1.3 Groundwater Monitoring

Groundwater monitoring for ISB will be performed in accordance with the *In Situ Bioremediation Remedial Action Groundwater Monitoring Plan for Test Area North, Operable Unit 1-07B* (INEEL 2003) to support performance and compliance monitoring and trending in support of the RAOs described in the 2001 Record of Decision Amendment (DOE-ID 2001b). Monitoring data will be collected and used to:

- Document concentration changes of COCs over time (including radionuclides)

- Evaluate ISB's ability to prevent the migration of VOCs from the hot spot (VOCs less than MCLs in TAN-28, TAN-30A, TAN-1860, and TAN-1861)

- Evaluate progress toward meeting the RAOs established in the Record of Decision Amendment (DOE-ID 2001b)

- Provide data that will be used to perform periodic reviews and evaluations.

The data to be collected from groundwater sampling activities include electron donor parameters, redox indicators, bioactivity and amendment indicators, ARD indicators, and radiological contaminant concentration data. These data will be generated from analytical procedures used in the field laboratory, INEEL Research Center laboratory, and other off-Site laboratories. Detailed information on analytical methods and data management is provided in the Groundwater Monitoring Plan (INEEL 2003).

1.4 Institutional Controls

Institutional controls will consist of engineering and administrative controls (such as locking doors, padlocks, signage, and controlled access) that will protect current and future users from health risks associated with groundwater contamination by preventing ingestion of groundwater having concentrations of COCs exceeding MCLs or having a cumulative carcinogenic risk greater than 1×0^{-4}. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) signage will be posted in accordance with 29 *Code of Federal Regulations* (CFR) 1910, "Occupational Safety and Health Standards." These controls will be implemented in accordance with the *Institutional Control Plan for the Test Area North Waste Area Group 1* (INEEL 2000). Project-specific institutional control activities that will be used in support of the ISB system operations are addressed in Section 5 of this O&M Plan.

2. FACILITIES AND EQUIPMENT

Operational resources required to implement the remedial action strategy include both personnel and physical infrastructure. This section discusses the facilities and equipment needed for ISB operations.

The primary facility required for implementation of the ISB remedial action strategy is the amendment injection system. Additional support facilities and equipment include a field laboratory, the existing CERCLA waste storage area (CWSA), and site utilities. An overview of each of the new infrastructure components is provided below.

2.1 Amendment Injection System and Enclosure

The amendment injection system is designed to inject amendments such as sodium lactate, whey powder, lactose powder, or molasses into the aquifer to enhance the growth of indigenous subsurface microorganisms that naturally dechlorinate trichloroethene (TCE), tetrachloroethene (PCE), dichloroethene (DCE), and vinyl chloride (VC) to the nonhazardous compounds ethene, ethane, chloride, carbon dioxide (CO_2), and water (H_2O). As observed during the ISB field evaluation, injected amendments also facilitate degradation of the secondary source material.

The facility is divided into three areas: (1) an amendment storage and process area, (2) a field laboratory, and (3) an office area. The new ISB building layout is shown in Figure 2-1. The amendment injection process flow diagram is shown in Figure 2-2. The injection system is comprised of a bulk bag unloader and handling system, amendment injection device (eductor or pump), flow controls, monitoring instrumentation, and piping. This system will inject the amendment solution at the desired concentration into any one of three injection wells, at a flow rate between 76 L/min (20 gpm) and 190 L/min (50 gpm). The list of major equipment is provided in Appendix B. The storage area can store up to 20 pallets of amendment.

2.2 Field Laboratory

The new facility includes a 250-ft^2 (23.2-m^2) field laboratory, which will allow chemical sampling analyses to be performed onsite. The following field analyses will be performed within the laboratory:

- Iron
- Phosphate
- Nitrogen, ammonia
- Alkalinity
- Sulfate
- Chemical oxygen demand.

The laboratory will house all the equipment required for groundwater sampling support such as water deionization apparatus, storage refrigerators and freezers, waste carboys and containers, fume hood with acid counter, sink, approximately 30 ft (9.14 m) of counter space, desk, and equipment storage cabinets.

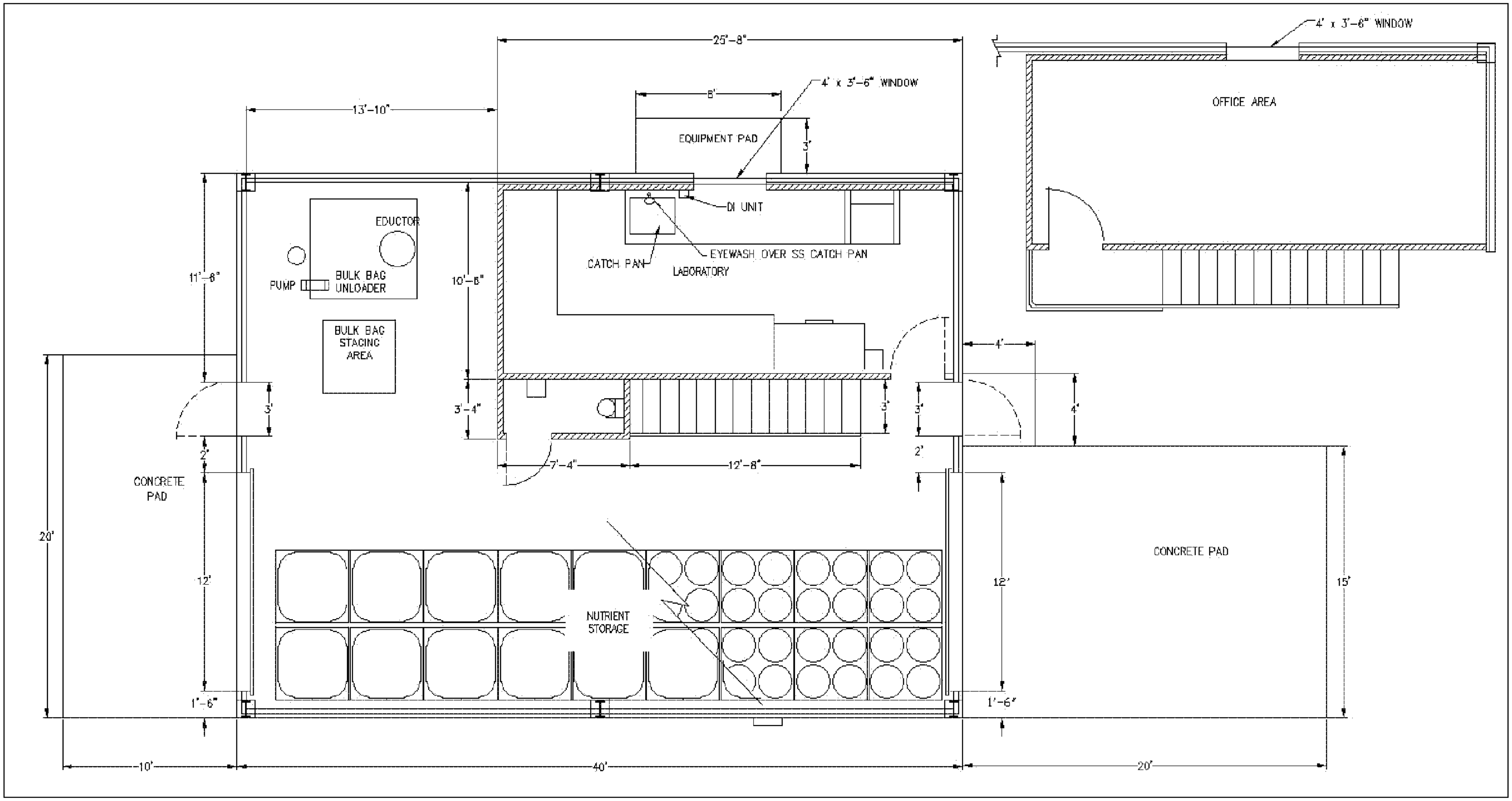

Figure 2-1. Building layout.

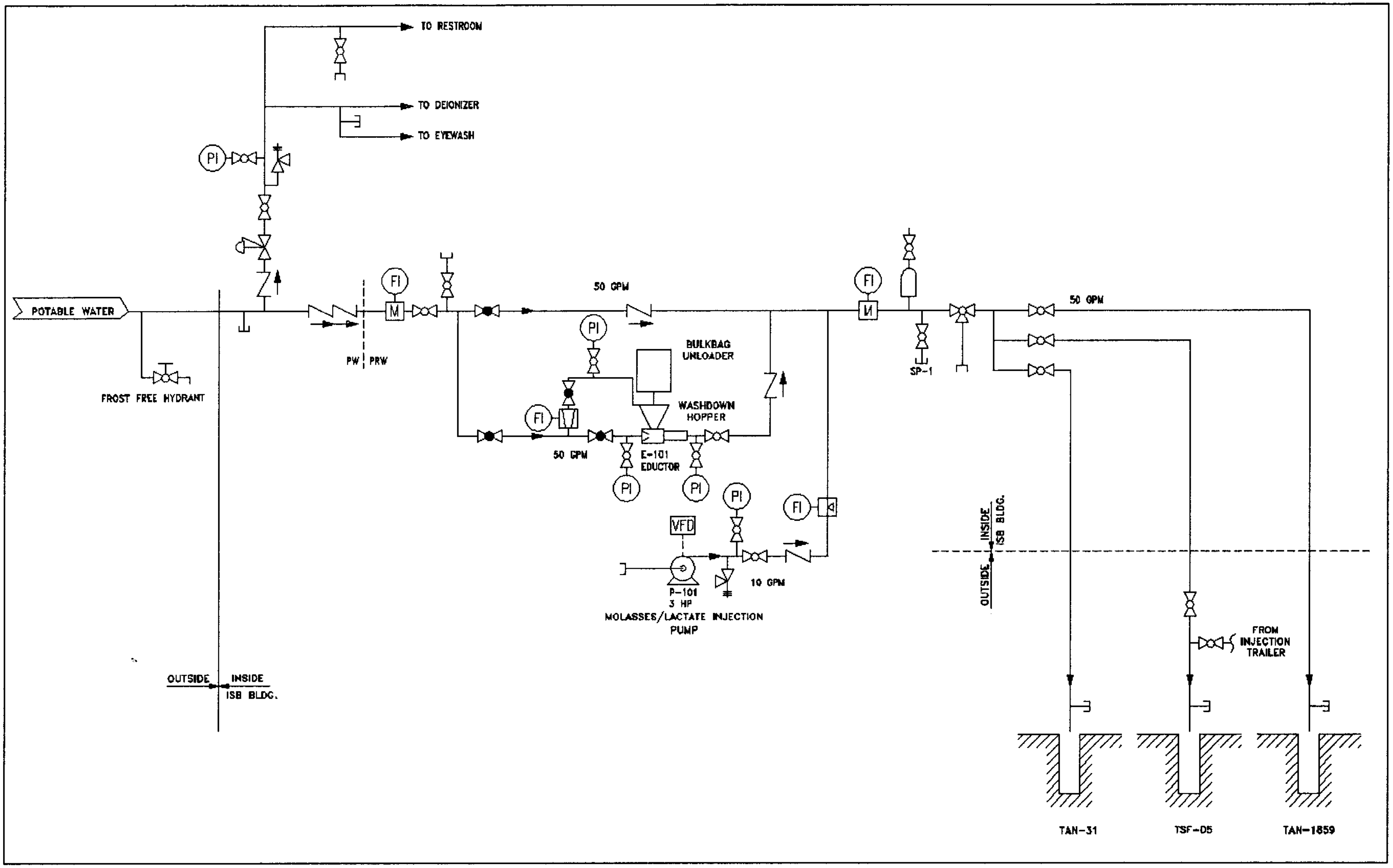

Figure 2-2. Process flow diagram.

2.3 Utilities

The TSF area at TAN is scheduled for deactivation sometime in the near future, at which time current facilities will be unavailable for use. Because of this, the only utilities and services available for the ISB project are potable water from the TSF potable/fire water distribution system and electrical service. Electrical service is obtained from the main 13,800-V line running adjacent to the OU 1-07B project area. Existing pole transformers installed for the Groundwater Treatment Facility that provide 480-V, 3-phase power will be used. Water is obtained from the TSF potable/fire water distribution system, which will be supplied by Wells TAN-1 and/or TAN-2. A site layout is shown on Figure 2-3.

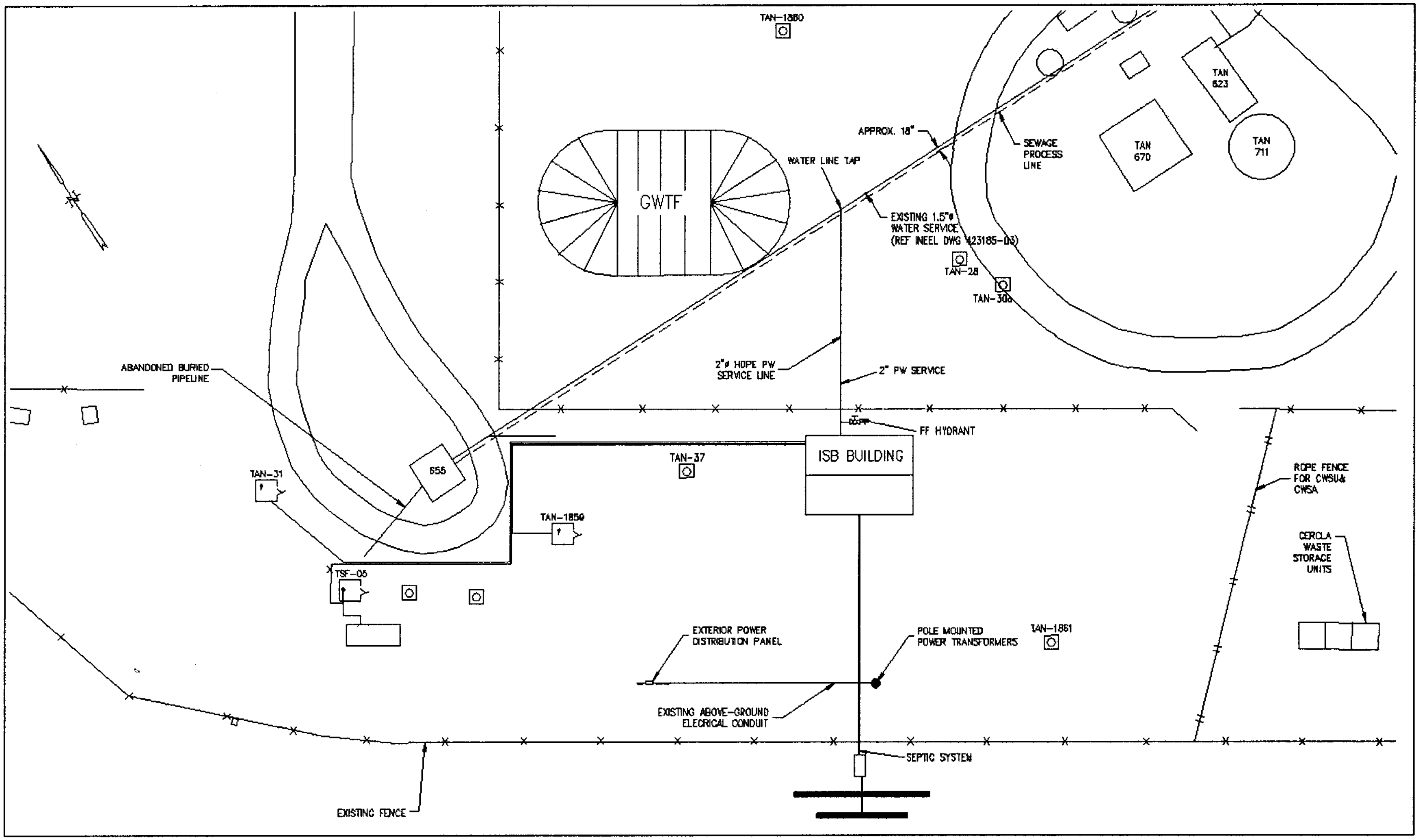

Figure 2-3. Site layout.

3. OPERATIONS AND MAINTENANCE

This section identifies the O&M requirements for the ISB system, including operational criteria and a description of the procedures that will be developed to operate and maintain the ISB system. All ISB operations will be performed in accordance with both CERCLA and INEEL work control requirements. The procedures for ISB activities were developed specifically in accordance with INEEL Management Control Procedure (MCP)-3562, "Hazard Identification, Analysis, and Control of Operational Activities," and the Conduct of Operations requirements, List (LST)-235, "Operable Unit 1-07B Conduct of Operations Conformance Matrix (DOE Order 5480.19)." Figure 3-1 shows the ISB document hierarchy, and Table 3-1 identifies all required procedures to be used for ISB operations. Specific aspects of ISB operations that are discussed in this section and are subject to the INEEL work control requirements include routine operations, inspections and maintenance (including spare parts inventory), and waste management.

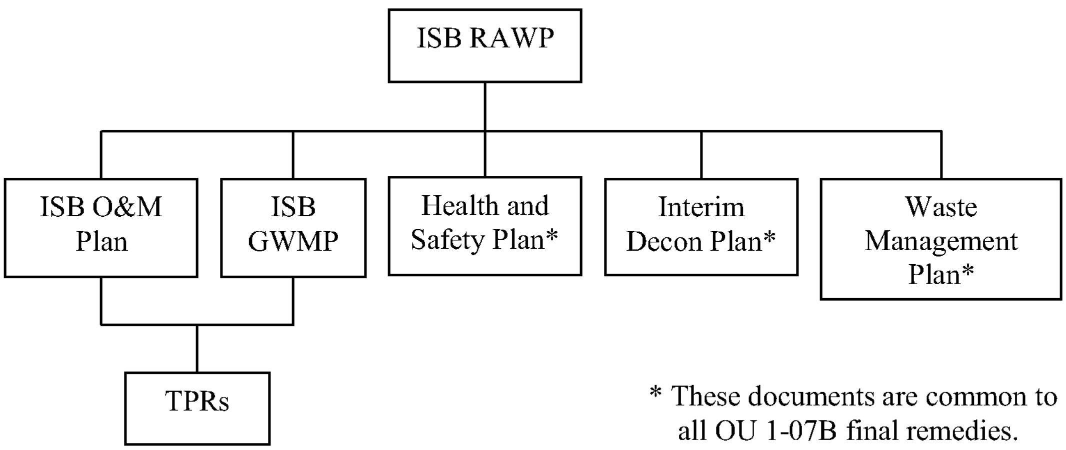

Figure 3-1. Document hierarchy.

Table 3-1. In situ bioremediation operations procedures.

ISB Operations Task	Operations Procedure
Amendment injection	TPR-6899, "In Situ Bioremediation Facility Aqueous Electron Donor Injection" TPR-6900, "In Situ Bioremediation Facility Solid Phase Electron Donor Injection
Sampling processes	TPR-165, "Low Flow Groundwater Sampling Procedure"
Laboratory processes	TPR-166, "In Situ Bioremediation Field Laboratory Procedure"
Troll operations	TPR-6247, "Operable Unit 1-07B Troll 9000 Water Quality Probe Operations and Maintenance"
Hydrolab operations	TPR-6248, "Operable Unit 1-07B Hydrolab Operation and Maintenance"
Training requirements	PDD-125, "OU 1-07B Test Area North Groundwater Remediation Project Training Program"
Preventative maintenance	TPR-6901, "In Situ Bioremediation Facility System Preventative Maintenance"
Safety equipment	TPR-6375, "Operable Unit 1-07B Facility Operations Eye Wash and Fire Extinguisher Inspection Procedure."

ISB = in situ bioremediation
OU = operable unit
TPR = technical procedure

3.1 Routine Operations

Routine operations for the ISB system include amendment injection, sampling, field laboratory analysis, and waste handling. The purpose of the procedures for these activities is discussed below.

3.1.1 Amendment Injection Procedure

Technical Procedure (TPR) -6899, “In Situ Bioremediation Facility Aqueous Electron Donor Injection,” and TPR-6900, “In Situ Bioremediation Facility Solid Phase Electron Donor Injection,” provide project personnel guidance on routine operations for injecting amendment solution into the various injection wells. This may include, but is not limited to, the following:

- Startup, operation, and shutdown of the amendment injection system
- System equipment inspections and routine adjustments.

The actual injection strategies including the amendment used, amendment quantity, solution concentration, and injection location may change during the initial and optimization phases of operations.

3.1.2 Sampling Procedure

The “Low Flow Groundwater Sampling Procedure” (TPR-165) provides the guidance required to perform ISB sampling activities. This includes the steps required for equipment calibration and deployment, as well as sample collection and preparation.

3.1.3 Field Laboratory Procedures

The “In Situ Bioremediation Field Laboratory Procedure” (TPR-166) provides the guidance required to perform laboratory analyses, including:

- Iron
- Phosphate
- Nitrogen, ammonia
- Alkalinity
- Sulfate
- Chemical oxygen demand.

“Operable Unit 1-07B Troll 9000 Water Quality Probe Operations and Maintenance” (TPR-6247) and “Operable Unit 1-07B Hydrolab Operation and Maintenance” (TPR-6248) provide instructions for deploying, maintaining, calibrating, and programming the Troll and Hydrolab instruments. These procedures include the steps required for their care, preparation for deployment, and use.

3.2 Inspections and Maintenance

Procedures used for ISB maintenance activities will be developed in accordance with either MCP-3562, “Hazard Identification, Analysis, and Control of Operational Activities,” or Standard

(STD) -101, “Integrated Work Control Process.” The maintenance strategy for the ISB system will consist of periodic preventative maintenance and corrective maintenance, as needed. Preventative maintenance will be performed on the pumps and flow control equipment, as recommended by the manufacturers. The following sections identify the procedures used in inspection and maintenance activities for ISB.

3.2.1 Safety Equipment Inspections

“Operable Unit 1-07B Facility Eye Wash, Emergency Light/Exit Sign, Fire Extinguisher, and First Aid Kit Inspection Procedure” (TPR-6375) provides the instructions for the inspection and maintenance of safety equipment, which includes eye wash bottles, portable fire extinguishers, and emergency lights, and the steps to be taken when an emergency indicator is triggered or an abnormal condition occurs. During the safety equipment inspection, a walk-down of the facility also will occur to look for any obvious signs of abnormal wear and tear to the building. Observations and inspections will be performed periodically, as shown in Table 3-2.

Table 3-2. Routine inspection and maintenance schedule.

Equipment	Frequency
Hi-viscosity liquid injection pump	Annually
Bulk bag unloader	Annually
Hoist and trolley	Prior to each solid phase injection event
Overhead doors	Annually
Facility walk-down	Monthly
Spare parts	Annually
Eye wash station	Semiannually
Emergency lighting	Monthly
Fire extinguishers	Quarterly
First-aid kit	Monthly

3.2.2 Routine Maintenance

“In Situ Bioremediation Facility Prevention Maintenance” (TPR-6901) provides the guidance required to inspect and maintain the ISB equipment. Routine maintenance will be performed, as needed, for the process equipment. These activities will be based on observations made by the ISB operators during their operational inspections or on a minimum periodic frequency, as specified in Table 3-2.

3.2.3 Calibration

Table 3-3 lists the instruments and associated calibration frequency required for the ISB system. Each item that requires calibration (except Hydrolabs) will be recalibrated, at the least, on an annual basis.

Table 3-3. Calibration requirements.

Instrument	Calibration Frequency
Hydrolabs	Every 2 months
Pressure indicators	Annually

3.2.4 Corrective Maintenance

Corrective maintenance primarily consists of unplanned repairs or replacement of system components after degradation has been observed or failure has occurred and will be performed on a case-by-case basis. Examples of these include worn-out pumps, leaky pipes, and failed electronic equipment. These maintenance activities will be performed in accordance with STD-101, "Integrated Work Control Process."

All corrective measures will be documented in the facility logbook. Review of the maintenance logbooks will be performed periodically to see if there are any specific trends or problems that could be corrected with a system modification. Any system improvements or modifications shall be performed in accordance with applicable INEEL procedures (e.g., MCP-2811, "Design Control," and STD-101, "Integrated Work Control Process").

3.2.5 Freeze Protection

The ISB system has been designed to allow operation through the winter months at the INEEL. The system is designed in such a way that piping subject to freezing is routed underground and can be drained enough to prevent piping ruptures subsequent to each injection event. As described in the TPR-6899 and TPR-6900 amendment injection procedures, measures will be taken after each injection event to remove all process water from the system components and piping. This will remove the risk of pipes freezing during both planned and unplanned power outages.

3.2.6 Spare Parts Inventory

A spare parts inventory will be maintained at the ISB system building and will be inspected as a part of TPR-6901. The recommended spare parts list is included in Appendix C.

3.3 Waste Management

The In-Situ Bioremediation Remedial Action Work Plan (DOE-ID 2003) addresses the general requirements for all waste generated during the OU 1-07B hot spot remedial action, including waste generated during O&M. Specific waste management requirements are covered in the *Waste Management Plan for Test Area North Final Groundwater Remediation Operable Unit 1-07B* (INEEL 2002b). The waste streams expected to be generated by ISB operations are listed below:

- Nonhazardous CERCLA waste
- Sampling personal protective equipment
- Sampling purge water
- Laboratory waste (hazardous and nonhazardous).

4. DATA EVALUATION AND OPERATIONAL DECISION-MAKING

As described in Table 2-1 of the In Situ Bioremediation Remedial Action Work Plan (DOE-ID 2003), data evaluation is performed to support performance, compliance, and completion monitoring. Figure 4-1 shows the ISB data evaluation process that will be implemented for this project. The data evaluation process includes reviewing and interpreting data, evaluating system performance, and recommending adjustments to operational parameters, if necessary. The data evaluation process is discussed below.

4.1 System Monitoring Parameters

The operating performance of the ISB system will be evaluated using a number of different parameters. These parameters will be used during interim, initial, optimization, and long-term monitoring operations. Evaluations and trending of these parameters will be used to evaluate the compliance and performance objectives established in Table 2-1 of the In Situ Bioremediation Remedial Action Work Plan (DOE-ID 2003) to represent completion of the different operational phases and to determine the success of meeting the RAOs. The following sections discuss the system monitoring parameters used for sodium lactate injections. The applicability of these parameters may change slightly if alternate amendments are used. An evaluation of the monitoring parameters will be performed if alternate amendments are to be used in the field.

4.1.1 Amendment Parameters

Spatial and temporal trends in amendment parameters, based on chemical oxygen demand and individual volatile fatty acids, will be used to ensure that the appropriate electron donor utilization conditions exist to support efficient ARD of chloroethenes in the ISB treatment cell. Amendment parameters and trends used for performance monitoring are described in the following subsections.

4.1.1.1 Distribution. All wells will be monitored for chemical oxygen demand or specific electron donors (such as lactate, propionate, acetate, and butyrate) to ensure that the electron donor is distributed throughout the entire area impacted by the secondary source.

4.1.1.2 Concentration of Lactate. If the ISB treatment cell is operating efficiently, concentrations of lactate should only be detected immediately following an injection. If lactate is present in the treatment cell for longer than a month after injection, then it indicates that the fermentation process is continuing over a significant period of time after injection. As shown in past operations, the most efficient ARD is obtained by maintaining rapid fermentation of lactate to propionate. Changes to the operating strategy should be considered if lactate concentrations persist between injections.

4.1.1.3 Concentration of Propionate. The relatively slow fermentation of propionate produces hydrogen to facilitate ARD reactions while avoiding potential competition issues with methanogens. If the injection strategy is operating efficiently, the rapid fermentation of lactate will produce significant concentrations of propionate throughout the treatment cell. Concentrations of propionate will be highest near the injection location, but significant concentrations need to be distributed throughout the source area in order for ARD to reduce the contaminant concentration flux from the source. If proper distribution is not indicated by significant downgradient concentrations of propionate in wells such as TAN-37A, then a change to the operational strategy should be considered.

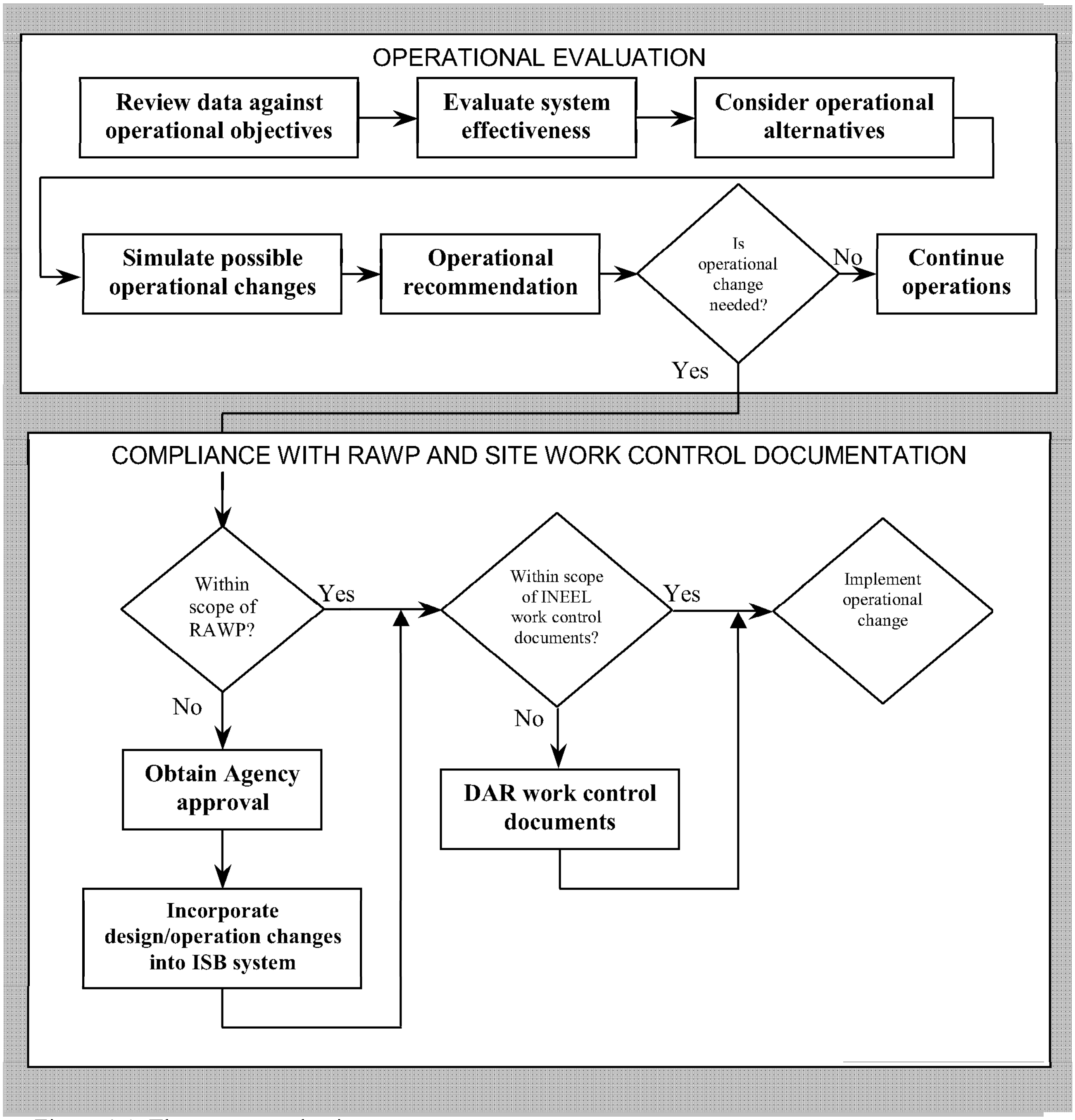

Figure 4-1. The system evaluation process.

4.1.1.4 Molar Ratio of Propionate:Acetate. The molar ratio of propionate:acetate also is used to assess the effectiveness of the lactate injection strategy for creating propionate fermentation conditions. This ratio should increase approximately one to two weeks following each lactate injection then rapidly drop as propionate fermentation becomes a dominant activity. This behavior should be observed throughout the source area, indicating electron donor utilization conditions are appropriate for efficient ARD of TCE. If this pattern is not observed, then changes to the operational strategy should be considered.

4.1.2 Redox Parameters

4.1.2.1 Concentration of Sulfate and Methane. Methanogenic conditions must be present for ARD to completely degrade TCE and to create appropriate electron donor utilization conditions throughout the source area. Methanogenic conditions are indicated by an absence of sulfate (and other electron acceptors) and the presence of methane. If the presence of sulfate and/or absence of methane are observed in downgradient monitoring wells such as TAN-37A, a change to the operational strategy should be considered.

4.1.3 Dechlorination Parameters

4.1.3.1 Molar Concentrations of Trichloroethene, cis-Dichloroethene, Vinyl Chloride, and Ethene. Downgradient concentrations of TCE, cis-DCE, and VC should decrease to levels at or near detection limits, while downgradient ethene concentrations should increase and remain relatively high. If significant concentrations of TCE and cis-DCE are present in the downgradient wells (such as TAN-28, TAN-30A, and TAN-37A) and in transverse monitoring wells (such as TAN-1860 and -1861), then ARD is not occurring throughout the entire residual source area, and TCE and cis-DCE are being dissolved from the region of the source area not affected by ARD. In this case, the operational strategy should be changed so that the size of the ARD zone will increase to encompass the entire residual source area.

4.1.4 Bioactivity Parameters

4.1.4.1 Alkalinity and Concentrations of Phosphate and Ammonia. Alkalinity and the concentration of phosphate and ammonia can be used to evaluate activity of microbial populations. Alkalinity, a bioactivity parameter and indicator of microbial respiration, is increased by the fermentation of lactate and propionate. This provides an indication of whether electron donor utilization is occurring in the treatment cell. Phosphate and ammonia are nutrients required for microbial growth and are monitored to ensure that microbial populations are not nutrient-limited.

4.1.5 Radionuclide Parameters

During the original waste injection activities, tritium was injected along with the VOCs into TSF-05. Because the ISB process does not affect tritium, it can serve as an indicator of contaminant concentration flux from the source material. Concentrations of tritium throughout the treatment cell can be compared to concentrations of VOCs to assess the extent to which partitioning of VOCs is enhanced due to ISB.

4.1.6 In Situ Parameters

In situ data can be used to observe conditions in select monitoring wells throughout the treatment cell. In situ data include dissolved oxygen, temperature, pH, specific conductance, and oxidation-reduction potential. The change in these parameters is useful for monitoring the arrival of sodium lactate at a particular monitoring well, thereby determining the extent of amendment distribution.

4.2 Process Data Evaluation

Data collected in accordance with the Groundwater Monitoring Plan (INEEL 2003) are used to support the data evaluation process for ISB. The data evaluation will include activities such as creation of charts, review and interpretation of data, and performance simulation analysis. Trends in various parameters over time (such as amendment distribution, redox conditions, bioactivity indicators, and radionuclide concentrations) will be evaluated to determine the performance of a given amendment injection strategy. Electron donor charts indicate whether amendment distribution throughout the treatment cell is adequate. The concentrations of individual volatile fatty acids are used to monitor for appropriate amendment utilization conditions in support of the most efficient conditions for ARD of TCE. In order for ARD of TCE to be energetically favorable, redox conditions must be methanogenic. For this reason, redox charts showing concentrations of iron, sulfate, and methane can be used to assess redox conditions throughout the treatment cell and predict where ARD is likely to occur.

Molar concentrations of PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, VC, and ethene can be plotted at each well to assess the efficiency of ARD reactions throughout the treatment cell and to ensure that ISB discontinues flux of VOCs from the hot spot. Molar concentrations are used to assess the mass balance of the ARD reaction, because a perfectly efficient ARD reaction will produce equivalent molar concentrations of ethene as that of the original TCE concentration. In the TAN system, the molar concentrations of ethene are significantly higher than those of the original TCE in the hot spot wells, indicating ISB is enhancing the degradation of source material and not just removing the TCE that is dissolved in the water. Molar concentrations of individual chloroethenes and ethene can be used to verify that ISB continues to enhance both partitioning and biodegradation of VOCs from source material.

4.2.1 Performance Simulations

Performance monitoring results will be used to update the ISB numerical model. The numerical model will be used to simulate ISB performance under various conditions. The results of these simulations will be used to predict amendment distribution and trends in other parameters. These simulations, along with the system monitoring parameters described above, will be used to evaluate possible operational changes in amendment injection and sampling.

4.2.2 Operational Changes

Results of the data evaluation, along with the results of the performance simulations, will be used to develop recommended actions for operational changes, if needed. The data will be compiled and summarized and included in the Annual Performance Report for ISB. An evaluation will be performed to determine if the operational changes can be implemented under the existing work control documentation and/or if they are within the scope of the current Remedial Action Work Plan. If changes to the Remedial Action Work Plan are required, the proposed change will be presented to the Agencies for approval and implemented only after approval is received and controlling documents are updated, as required. All proposed changes will be reviewed against the INEEL work control documents and revisions will be made, as necessary.

5. INSTITUTIONAL CONTROLS

Institutional controls will consist of engineering and administrative controls to protect current and future users from health risks associated with groundwater contamination by preventing ingestion of groundwater having concentrations of COCs exceeding MCLs or having risk-based concentrations for all contaminants greater than 1×10^{-4}. Access to water within the plume that has contaminant concentrations greater than MCLs will be placed under institutional controls until MCLs and the required risk-based concentrations are achieved.

The institutional controls for the ISB system will be maintained in accordance with the Waste Area Group 1 Institutional Control Plan (INEEL 2000) and will ultimately tie into the overall Waste Area Group 10 Sitewide Institutional Control Plan.

5.1 Administrative Controls

Administrative controls shall include placing written notification of this remedial action in the facility land use master plan. The notification shall include the following:

- Identify/map the area of contamination using both U.S. Geological Survey coordinates and state plane coordinates; this map must include the anticipated maximum 30% growth of the plume.
- Prohibit installation of any drinking water wells accessing the aquifer within the contaminated plume and buffer zone, as described in the 2001 Record of Decision Amendment (DOE-ID 2001b).
- Prohibit engaging in any activities that would interfere with the remedial activity.

A copy of the notification shall be given to the U.S. Bureau of Land Management (BLM), together with a request that a similar notification be placed in the BLM's property management records for this site. The U.S. Department of Energy (DOE) shall provide the U.S. Environmental Protection Agency and the State of Idaho with written verification that notifications, including BLM notification, have been fully implemented. This notification will be given prior to commencement of initial operations and concurrently with the submittal of each 5-year review.

5.2 Engineering Controls

Engineering controls shall consist of installing devices and controls to restrict access to water from within the contaminated plume. The devices shall include, but may not be limited to, the following:

- Controlled access to the injection facility and the CWSAs (with padlocks and locking doors)
- Controlled access to the well heads (with locking doors)
- Signs and postings at the injection facility and the CWSAs (CERCLA signage to be posted in accordance with 29 CFR 1910, "Occupational Safety and Health Standards")
- Postings on wellheads identifying potential hazards.

6. DECONTAMINATION AND DECOMMISSIONING

The In Situ Bioremediation Remedial Action Work Plan (DOE-ID 2003) addresses the general requirements for interim decontamination of temporary project equipment and final deactivation, decontamination, and decommissioning. Specific requirements for interim decontamination of temporary project equipment are addressed in the *Interim Decontamination Plan for Operable Unit 1-07B* (INEEL 2002c). Final deactivation, decontamination, and decommissioning of the ISB remediation facilities will be addressed in accordance with the In Situ Bioremediation Remedial Action Work Plan (DOE-ID 2003).

7. SAFETY, HEALTH, AND QUALITY

General safety and health program requirements are addressed in the In Situ Bioremediation Remedial Action Work Plan (DOE-ID 2003). Specific health and safety requirements are covered in the *Test Area North Operable Unit 1-07B Final Groundwater Remedial Action Health and Safety Plan* (INEEL 2002d), which has been prepared to meet the requirements of the Occupational Safety and Health Act standard, 29 CFR 1910.120/1926.65, "Hazardous Waste Operations and Emergency Response." The Health and Safety Plan governs all work that is performed by employees of the management and operations contractor, subcontractors, or subtier subcontractors to the management and operations contractor, and employees of other companies, or DOE laboratories. In general, it is the responsibility of the ISB operators to ensure that only well-planned and safe activities are performed within the facility, including the following:

- Injection facility O&M activities
- Groundwater monitoring
- Other activities performed within the plume.

The facility is equipped with fire extinguishers, an eye wash station, and an emergency lighting system. Proper signs, markings, and labels have been used to identify items or areas that may pose some safety risk if the operators are unaware of them. Possible hazards within the injection facility include the following:

- Tripping/falling hazards (e.g., pipes, door jams)
- Pressurized water
- Electrical equipment and wiring.

Other hazards associated with the field laboratory include the following:

- Radiological contamination
- VOC inhalation
- Methane.

General quality assurance requirements for ISB are addressed in the In Situ Bioremediation Remedial Action Work Plan (DOE-ID 2003). The most important activities associated with ISB O&M activities and groundwater monitoring with respect to quality assurance are sample collection and analysis for compliance, performance, and groundwater monitoring. The quality assurance requirements for groundwater monitoring are covered in the Groundwater Monitoring Plan (INEEL 2003).

8. REPORTS

This section provides a summary of the reporting requirements for ISB O&M activities.

8.1 Remedial Action Report

As specified in the Remedial Design/Remedial Action Scope of Work (DOE-ID 2001a), a Remedial Action Report will be prepared for the ISB system after the project's optimization phase. The Remedial Action Report will be a primary document with draft, draft final, and final submittals. The milestone date for this document will be established, based on optimization phase completion.

The Remedial Action Report will address the following:

- Summary of remedial action components, as defined in the In Situ Bioremediation Remedial Action Work Plan (DOE-ID 2003)
- Explanation of changes to the remedial design and In Situ Bioremediation Remedial Action Work Plan (DOE-ID 2003)
- Summary of the results of operational testing and the final inspections
- Evaluation of the effectiveness in meeting performance requirements
- Documentation of closure of any open action items from the prefinal and final inspection reports
- Summary of data collected during operations that supports a determination that the remedy is functional and operational
- Determination of the method for evaluating achievement of secondary-source degradation
- Certification that the remedy is functional and operational
- An In Situ Bioremediation Remedial Action Work Plan update, if necessary
- An In Situ Bioremediation Operations and Maintenance Plan update, if necessary
- An In Situ Bioremediation Groundwater Monitoring Plan update, if necessary.

8.2 Annual Performance Reports

The Annual Performance Report will combine information from groundwater monitoring, operations, and performance reviews of ISB. Groundwater monitoring will be conducted in accordance with the requirements set forth in the Groundwater Monitoring Plan (INEEL 2003), while reports will be prepared in accordance with the In Situ Bioremediation Remedial Action Work Plan (DOE-ID 2003). Annual monitoring reports will be included in the prepared Annual Performance Report and will discuss groundwater analytical and elevation data from the monitoring activities. Electronic files of the data will be provided with the report. This information will present a historical perspective and trend analysis of monitoring results.

The operations information included in the Annual Performance Report will be a summary of the ISB system operations, including any abnormal operating situations encountered, modifications made to operational parameters, etc. The operations reports will be condensed and included in the Annual Performance Report.

After the ISB system begins operations, annual performance review reports will be written. These reports will be used to support the periodic performance reviews and will include evidence of ISB regulatory performance and compliance with RAOs, budgetary performance, and institutional controls. Operational modifications or optimization activities implemented as a result also will be described. The annual report for each of the final remedial components will then be compiled into the annual remedy performance summary report, which will in turn be used in support of the Agency periodic performance reviews.

8.3 Operations and Maintenance Report

As addressed in the Remedial Design/Remedial Action Scope of Work (DOE-ID 2001a), an O&M Report will be prepared and submitted to the Agencies at the completion of all O&M activities. The O&M Report will be a primary document and will include a draft, draft final, and final submittal. The purpose of the O&M Report will be to provide information that will support an Agency decision that the active remedial action has been successful in meeting the RAOs. This will include information indicating that the VOC concentration in the contaminated groundwater plume immediately adjacent to the source, and in the source itself, has been:

- Reduced to below MCLs
- Reduced to a cumulative carcinogenic risk of less than 1×10^{-4}
- Reduced to a hazard index of less than 1.

It is anticipated that natural attenuation will cause the remaining portions of the plume to reach MCLs within the established restoration timeframe. The report also will provide the handoff to the Long-Term Stewardship long-term monitoring plan and subsequent INEEL-wide 5-year reviews to ensure that long-term monitoring continues to provide evidence that contaminant concentrations will be reduced to MCLs throughout the entire plume within the remedial timeframe. Finally, the O&M Report will provide a final deactivation, decontamination, and decommissioning plan for the OU 1-07B treatment facilities. The O&M Report will include the following:

- Description of O&M activities performed
- Results of remedy performance monitoring
- Summary of the Long-Term Stewardship long-term monitoring strategy
- Decontamination and decommissioning plan.

The draft final and final documents will include responses to Agency comments. The submittal date for the O&M Report will be established after submission of the Remedial Action Report in the revision of this O&M Plan. The OU 1-07B Record of Decision (DOE-ID 1995) assumed that ISB operations would continue through Fiscal Year 2018. Based on this assumption, it is anticipated that the submittal date for the O&M Report will be set in one of the INEEL periodic review reports submitted during or before the year 2020. However, this date is subject to change based on the long-term progress of ISB.

9. REFERENCES

29 CFR 1910, 2004, "Occupational Safety and Health Standards," *Code of Federal Regulations*, Office of the Federal Register, February 2004.

29 CFR 1910.120, 2004, "Hazardous Waste Operations and Emergency Response," *Code of Federal Regulations*, Office of the Federal Register, February 2004.

29 CFR 1926.65, 2002, "Hazardous Waste Operations and Emergency Response," *Code of Federal Regulations*, Office of the Federal Register, December 2002.

DOE O 5480.19, 2001, "Conduct of Operations Requirements for DOE Facilities," U.S. Department of Energy, October 23, 2001.

DOE-ID, 1991, *Federal Facility Agreement and Consent Order for the Idaho National Engineering Laboratory,* Administrative Docket No. 1088-06-29-120, U.S. Department of Energy Idaho Operations Office; U.S. Environmental Protection Agency, Region 10; Idaho Department of Health and Welfare, December 4, 1991.

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INEEL, 2002b, *Waste Management Plan for Test Area North Final Groundwater Remediation Operable Unit 1-07B*, INEEL/EXT-98-00267, Revision 4, May 2002.

INEEL, 2002c, *Interim Decontamination Plan for Operable Unit 1-07B,* INEEL/EXT-97-01287, Revision 4, May 2002.

INEEL, 2002d, *Test Area North Operable Unit 1-07B Final Groundwater Remedial Action Health and Safety Plan*, INEEL/EXT-99-00020, Revision 2, November 2002.

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LST-235, 2003, "Operable Unit 1-07B Conduct of Operations Conformance Matrix (DOE Order 5480.19), "Revision 1, September 2003.

MCP-2811, 2001, "Design Control," Revision 7, *Manual 10A–Engineering and Research*, June 2001.

MCP-3562, 2003, "Hazard Identification, Analysis, and Control of Operational Activities," Revision 8, *Manual 9–Operations*, October 2003.

PDD-125, 2003, "Operable Unit 1-07B Test Area North Groundwater Remediation Project Training Program," Revision 0, October 2003.

STD-101, 2003, "Integrated Work Control Process," Revision 15, *Manual 6–Maintenance*, July 2003.

TPR-165, 2004, "Low Flow Groundwater Sampling Procedure," Revision 8, Idaho Completion Project, January 2004.

TPR-166, 2003, "In Situ Bioremediation Field Laboratory Procedure," Revision 5, Idaho Completion Project, October 2003.

TPR-6247, 2003, "Operable Unit 1-07B Troll 9000 Water Quality Probe Operation and Maintenance," Revision 0, Idaho Completion Project, October 2003.

TPR-6248, 2003, "Operable Unit 1-07B Hydrolab Operation and Maintenance," Revision 0, Idaho Completion Project, October 2003.

TPR-6375, 2004, "Operable Unit 1-07B Facility Eye Wash, Emergency Light/Exit Sign, Fire Extinguisher, and First Aid Kit Inspection Procedure," Revision 1, Idaho Completion Project, January 2004.

TPR-6899, 2004, "In Situ Bioremediation Facility Aqueous Electron Donor Injection," Revision 0, Idaho Completion Project, February 2004.

TPR-6900, 2004, "In Situ Bioremediation Facility Solid Phase Electron Donor Injection," Revision 0, Idaho Completion Project, February 2004.

TPR-6901, 2004, "In Situ Bioremediation Facility Preventative Maintenance," Revision 0, Idaho Completion Project, February 2004.

Appendix A

Document Basis

Appendix A

Document Basis

Paragraph	Requirement	Source Document
All paragraphs	The laboratory shall have documented instructions on the use and operation of all relevant equipment, on the handling and preparation of items, and for calibrations/verification, where the absence of such instruction could jeopardize the calibrations/verifications. All instructions, standards, manuals, and reference data relevant to the work of the laboratory shall be maintained up-to-date and be readily available to the staff.	DOE/ID-11015, *In Situ Bioremediation Remedial Action Work Plan for Test Area North Final Groundwater Remediation, Operable Unit 1-07B*, Revision 1.

Appendix B

Equipment List

Appendix B

Equipment List

Type	Location	Description
Pressure indicator	PI1 (powder line, pre-eductor)	Ashcroft pressure gauge, P/N 45-1279-04L-0/160, 1/2-in. NPT connection, 0–160 psig
	PI2 (powder line, washdown feed) PI3 (powder line, post-eductor) PI4 (hi-viscosity liquid amendment injection line)	Ashcroft pressure gauge, P/N 45-1279-04L-0/30, 1/2-in. NPT connection, 0–30 psig
Flow indicator	FI1 (potable water feed line) FI2 (process water injection line)	Rosemount magnetic flow meter, P/N 8711THE015U1N0 flowtube with P/N 8732CT12N0M4T1 transmitter, 1-1/2-in. integral mounting configuration
	FI3 (hi-viscosity amendment injection line)	MicroMotion coriolis flow meter, P/N R200S341NCAAEZZZZ R-series sensor with P/N 1700I11ABAEZZZ transmitter, 1-1/2-in. process connection, 1/2-in. NPT connection
Pump	P-101 (hi-viscosity amendment injection line)	Viking HD internal gear pump, P/N HL124AD, 1-1/2-in. NPT connection, 3 hp
Bulk bag unloader	SP-103 bulk bag unloader	VibraScrew Model II VHD bulk bag unloader with vibration discharge (2/3 hp) and hoist/trolley (3 hp)
	SP-103 powder screw feeder	VibraScrew VersiFeeder vibrating feeder with vibrator (3/4 hp) and surge hopper level probe
Eductor	E-101 (powder eduction)	Elmridge powder injection eductor, P/N FBTLSS5, 1-in. 150# ANSI RF flange inlet, 1-1/2-in. 150# ANSI RF flange suction and discharge, with 1-1/2-ft^3 washdown hopper, 1-1/2-in. 150# ANSI FF flange discharge
Backflow preventer	SP-104	2-in. reduced pressure principle backflow prevention assembly, 175-psi working pressure, bronze body, removable seat discs, replaceable seats, with isolation valves at each end, without strainer, Watts International, Series 009 M2QT
Vacuum breaker	SP-105	1-1/4-in. pressure-type vacuum breaker, Johnson, VBB-151
Deionized water equipment	SP-108	Barnstead D0800, 5–10 gph

Type	Location	Description
Fume hood	FH-1	Labconco 28044-00, 25 × 28 × 45-in. fiberglass hood with bypass airflow, fiberglass liner, tempered glass sash, and built-in 1/10-hp blower
Acid cabinet	SP-111	Labconco 35820-00, acid cabinet with flat epoxy work surface for 28-in. hood
ANSI = American National Standards Institute		

Appendix C

Spare Parts List

Appendix C

Spare Parts List

Type	Quantity	Description
Pressure indicator	1	Ashcroft pressure gauge, P/N 45-1279-04L-0/160, 1/2-in. NPT connection, 0–160 psig
	1	Ashcroft pressure gauge, P/N 45-1279-04L-0/30, 1/2-in. NPT connection, 0–30 psig
Pump	1	Viking HD internal gear pump, P/N HL124AD, 1-1/2-in. NPT connection, 3 hp

Appendix D

Agency Comments and Comment Resolutions
In Situ Bioremediation Operations and Maintenance Plan

Appendix D

Agency Comments and Comment Resolutions ISB Operations and Maintenance Plan

Comment No.	Section / Page No.	Comment	Resolution
EPA 1.	Section 1.1, 2nd Bullet 1-2	Project RAOs not listed or referenced. The project RAOs should be listed here.	Agree. RAO's will be added.
EPA 2.	Section 1.2.2 1-3	Although I agree that we are attempting to optimize the system during this period, and cannot lock in an injection strategy, we still need to identify a performance minimum during this optimization phase, e.g., At a minimum, "x" gallons of sodium lactate or equivalent shall be injected into well "y" at a frequency no less than every "z" months.	Agree. An operational minimum was stated for the first year of operation. The minimum will be quarterly injections consisting of 660 gallons (12 drums) of sodium lactate in a 2% equivalent lactate concentration at 20 gpm. This minimum requirement will be clarified in the document.
EPA 3.	Figure 1-1 1-4	All COCs need to meet the MCL and cumulative risk.	For the timeframe shown on the figure the flux is referring to VOC's only. It is agreed that all COC's must meet the criteria by the end of the Long Term Operations.
EPA 4.	Section 1.3 1-5	We also need to evaluate whether the concentration of radionuclides like Sr-90 and Cs-137 are declining so that their concentrations will be within risk-based limits at the end of the restoration period.	The way the text is written it includes all COC's (including Radionuclides) as needing to be monitored to document changing concentrations. This includes Sr-90 and Cs-137.
EPA 5.	Section 1.4 1-5	Project specific I.C.'s (e.g., sinage and how maintained) needs to be specifically described.	Text was added to identify that CERCLA Signage will be required in addition to locking well caps and enclosures and maintaining the existing access control.
EPA 6.	Section 5.1 5-1	I suggest that the notification to BLM be submitted periodically to avoid potential loss of institutional memory. The frequency could coincide with 5-year Reviews.	Agree. Text was added.
EPA 7.	Section 5.2 5-1	This list should be specific as to what will be the minimum requirements to meet protectiveness concerns.	A reference to signage requirements was added.

Comment No.	Section / Page No.	Comment	Resolution
EPA 8.	Section 8.2 8-1	The monitoring report should include a data compact disc preferably written in MS Excel.	Text was added to state that electronic data will be provided with the annual reports.
IDEQ 1.	Section 1.1 1-2	Add a bullet stating: Verification that enhanced mobilization of radionuclides (Sr-90 and Cs-137) is not occurring as the result of the ISB activities.	Radionuclide mobilization is a issue that will be monitored. The criteria as to what warrents the implementation of the contingency remedy will be addressed in the Work Plan. There is currently no compliance criteria established for this parameter.
IDEQ 2.	Section 1.3 1-5	Include radionuclides in the referenced COCs.	Text added that states that the COC's include the radionuclides.
IDEQ 3.	Section 3.3 3-4	The waste management plan for this facility should be site-specific. Therefore, additional details as to how the waste will be managed are needed in this document.	The OU 1-07B Waste Management Plan contains the specifics for the ISB waste streams. No change is required.
IDEQ 4.	Section 4.2 4-4	The fifth line has the misspelled word "givent," which should be corrected.	Text was corrected.
IDEQ 5.	Section 5.1 5-1	It is suggested that state plane coordinates also be provided for completeness. Also, include language that the map will include the anticipated 30% growth of the plume.	Text was added as suggested.
IDEQ 6.	Section 5.2 5-1	Describe how the access to the injections facility and well heads will be controlled.	Added text specifying access control measures that will be required.
IDEQ 7.	Section 8.1 8-1	Open action items from the prefinal and final inspections should be completed prior to the projected submittal of this report.	Agree. Text was clarified.
IDEQ 8.	Section 8.2 8-1	The third sentence requires editing to clarify what information will be included in the annual monitoring reports and in the Annual Performance Report. As stated, it is not clear.	Agree. Text was clarified.
IDEQ 9.	Section 8.3 8-2	The first sentence should state "it is anticipated" that natural attenuation….	Agree. Text was added.